Universitat de Lleida

TREBALL FINAL DE MÀSTER

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Titulació: Màster en Enginyeria Informàtica

Títol de Treball Final de Màster: TControl: A Tobacco-Quitting Support Platform

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Presentació

Mes: Setembre

Any: 2020

TControl: A Tobacco-Quitting Support Platform

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Abstract

Background. Nowadays, the healthy lifestyle is on the rise and tobacco is one of the most common problems that affect a large part of the population since it is a major risk factor for a wide range of respiratory and circulatory diseases in active and passive smokers. That is the reason why more and more people are deciding to quit their habit in search of a healthier life due to health problems or because they want to lead healthier lives. All of them should know that it is never too late to try it and that by leading healthy lifestyle habits and with the right support can make the process easier and more bearable. This is where TControl comes in, a platform focused on the process of tobacco-quitting and oriented to both professionals and patients through its web portal and its particular "mobile application".

Objective. Develop an efficient platform that facilitates the management of, and assistance to, people who want to quit smoking with an useful and easy to use mobile complement with to keep in touch patients with specialists while providing tips and customized features.

Methodology. We present TControl, web portal developed using Java and Grails, a Spring based framework, that allows specialists to manage and assist its current patients by compiling their medical history, tracking all the progress, providing tips and a multi-platform messaging service (mail, SMS and app). Also offers patients the possibility to keep in touch in a closer way with their medical responsible, while receiving useful tips and take profit from customized features through an useful and easy to use mobile complement.

Results. TControl keeps track of the smoke-quitting users, tracking their status, interpreting it, and offering advice and psychological support messages. It also provides a bidirectional communication channel between patients and clinicians via its mobile complement which it has been decided to develop on a platform whose stability and performance are proven by millions of users: Telegram.

Conclusions. TControl is a very useful platform for specialists and current patients that decide to start the difficult process of tobacco-quitting. Overall, TControl is a good tool that helps people improve their health.

Keywords: Smoking, Smoke-free, E-health, Healthy, Lifestyle

Contents

1. Background

Smoking kills. It may sound like a cliche or a sensationalist way to start an article, but if we analyze it in detail, we will see that is the best way to summarize it.
Smoking has been one of the main causes of health problems in recent decades. In the 20th century, it is estimated that around 100 million people died prematurely from tobacco-related causes [1], and these same estimates suggest that during the 21st century, it could reach 1 billion deaths [2] [3], as reported in the article *https://ourworldindata.org/smoking* and collected by the Global Burden of Disease study, published in the medical journal *The Lancet* [4] [5] according to which more than 8 million people died prematurely from tobacco-related causes in 2017.
The previous amounts, initially were centralized in countries classified as rich, but with the passing of time those catalogued as low income countries were more affected.
By 2017, 15% of global deaths were attributed to smoking, of which the older population was the most affected, since more than half of the population was over 70 years old.
One out of every five adults is a smoker, but it is important to note that these data also affect passive smokers, to have a clearer idea of the total effect of the 8 million of the previous study, approximately 7 were direct smokers and 1 were passive smokers or what is the same, from 15% of global deaths in 2017, 13% were direct smokers while the remaining 2% were passive smokers.
Other studies have also found that men are much more likely to smoke than women. [6] [7]

Smoking is a risk factor for several of the main causes of death in the world, including lung cancer and other forms of cancer [8] as well as heart and respiratory diseases [9].

The following chart 1 shows the ranking of deaths by cause in 2017, in which smoking is in second position.

It has always been mainly related to lung cancer with which there is a close relationship between the periods of increased popularity/fashion of smoking and later the increase in cases of this disease, as can be seen in the referenced graphs which reflect the relationship between increased sales of cigarettes and increased deaths from lung cancer [10] [11].

The good news is that these deaths have been decreasing for decades throughout the world. This is mainly due to the increase in aid and treatment for those people who want to stop smoking, as well as prevention/anti-smoking campaigns among which we can find public awareness campaigns, talks in schools, scientific studies and others, as well as the increase of penalization against tobacco advertising (one of the mythical examples would

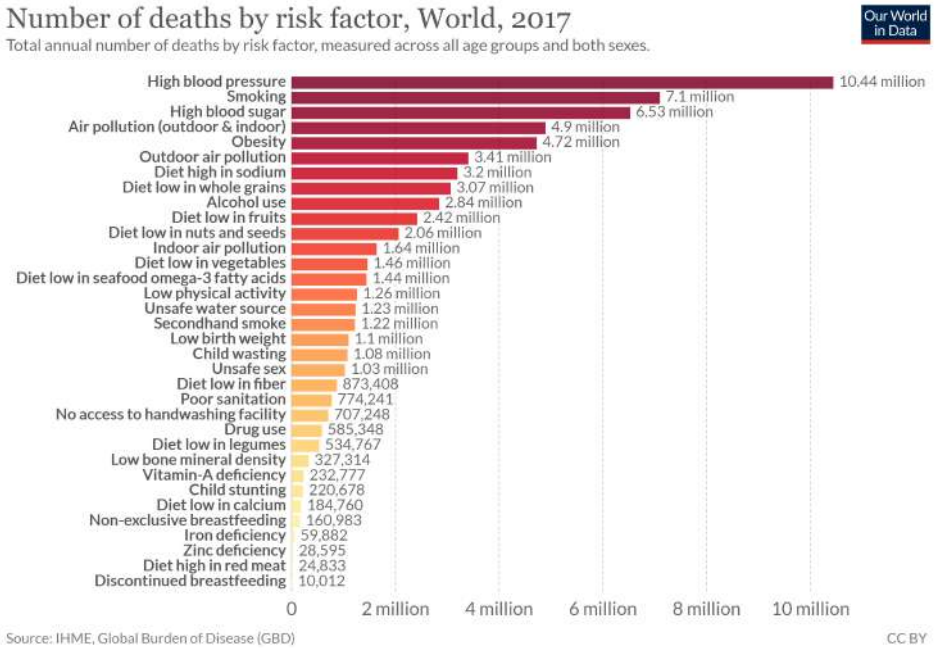


Figure 1: Ranking of deaths by cause, 2017.

be the moment when the Ferrari team is forced to remove the logo of the famous Marlboro cigarette brand from its Formula 1 car, one of their main sponsors, fact which was not exempt from controversy, since in repeated occasions it has been denounced that they continue showing references to the brand of cigarettes in a subliminal way, since at the moment the two brands haven't parted ways [12] [13]) and finally, but not less important, the bids of taxes on this product.

Public and private medical institutions in an increasing number of countries provide services for people that want to quit the habit of smoking. NRT (Nicotine Replacement Therapy), in the form of nicotine patches and/or nicotine gum, is effective to treat the short-term nicotine withdrawal. Depending on the treatment and replacement, the chances that patients succeed in quitting smoking are increased between 50% and 70% upon NRT [14]. However, NRT alone becomes ineffective after about 8 weeks of starting the treatment and its effect in maintaining a smoke-free patient over a longer period of time (years) appears to be quite modest, as demonstrated by meta-analysis of different studies [15, 16]. In light of this, some countries, such as the USA [17], the UK [18] and Australia [19], have published evidence-based guidelines to recommend effective tobacco cessation interventions ranging from brief instructions for quitting to extensive counseling combined with pharmaceutical adjuncts [20].

Because of the social context of tobacco smoking and extension of tobacco

addiction in the population, it is not feasible to provide general cessation programs where patients are interned and only return to the streets upon completion of the program. A major issue in the treatment of addictions, and in smoking cessation, is the high relapse rates. There can be several reasons: decrease of the initial motivation, carelessness, yielding to peer pressure in certain situations (parties, dinners, situations of anxiety or relaxation), a conscious decision by the patient to start smoking again, craving, among others. A factor that can help in these situations is to develop a strong therapeutic link between the patient and the medical service. Strategies that favor this situation may have a positive impact on the obtained results regarding the long-term tobacco abstinence.

Focusing in tobacco-quitting programs, patient-doctor contact and follow-up are very important psychological aspects of the process of quitting smoking, because they provide support and help maintain patient reinforcement [21, 23]. For example, a recent study [24] confirmed that proactive telephone counseling is effective in the short-term reduction of cigarette consumption and in increasing the percentage of smokers who attempt to quit by more than 5%, when compared to people without phone counseling. In addition, it was found that text messaging can double the likelihood of smoking cessation for patients that have neither continuous contact with their caregivers nor personalized follow-up [26]. This is consistent with the finding that smoking cessation interventions via mobile phone-based text messaging have a positive effect on long-term patient outcomes [31]. For example, S-PC [32] is a web-based e-medicine service that manages a central database of information on patient progress in a smoke quitting program being run at the public hospital Santa Maria in Lleida, Spain. Originally, S-PC uses mobile text messaging to follow up and manage patient progress. It evolved and became integrated in SHUITE (Simple Health Universal and Integral Treatment Environment), a non-free "Software as a Service" cloud framework responsible for managing patient and clinical information. Thus, depending on the penetration of mobile phone usage, having Apps that automatically manage smoke quitting patients and their patient-doctor communication might be a very effective way to improve smoke quitting treatment outcomes. That penetration appears to be high. For example, 90% of U.S. adults use a mobile phone. 64% of those adults have smartphones that are also used as their primary source of Internet connectivity [33]. Furthermore, 62% of smartphone users use that phone to look up information about a health condition [34]. Spain has the second highest smartphone penetration in the world, and 88% of the Spanish population owned a smartphone in 2015, up 3% from 2014 and 19% from 2013 [35] and according to Cisco Global Mobile Data Traffic Forecast [25], the number of mobile devices per inhabitant will reach 1.5 by 2021. In addition, 70% of Spanish smartphone users connected to Internet daily through this device. More than half of these users navigate for more than thirty minutes. There are documented ben-

efits for smoke quitting patients of keeping patient-doctor contact through text messaging and there is a high penetration of smartphones [26]. Hence, developing Apps for automating the contact and follow-up between patient and doctor during the process of quitting smoking could have significant impacts in smoke quitting programs in the Spanish health system.

Taking all this into account we set out to evolve S-PC and SHUITE into TControl a platform that supports cessation programs that can combine pharmacological treatment therapy with a simultaneous psychological treatment to control the progress and reinforce the motivation of the patient, based on a computer program that manages a central database of information on patient progression and strongly focused on patient-doctor communication.

2. Objective

To develop a useful, user-friendly UI, robust and efficient healthy platform to:

- Be generally applicable in smoking cessation treatment programs.
- Automate much of the work that needs to be done by the clinicians.
- Allow professionals to maintain an efficient and personalized support and follow-up of patients.
- Give patients the psychological support required to stop smoking successfully.
- Make patients feel closer with their medical responsible.
- Decrease the time clinicians need for managing the patients and reduce the average length of waiting lists.

In this article we present TControl, the evolution of S-PC and SHUITE integration, while we study its stability, usability and performance.

3. Related Work

First, we took a look to the current state of the market in tobacco-quitting systems and apps to compare it with TControl.
The most important systems that perform a function similar to that of TControl are STOMP [27], PMC [28], txt2stop [26], Quit Genius [29] and of course S-PC [32]. TControl is the system with the more complete set of functionalities. The physical medium used by each of the applications varies. PMC uses e-mail to exchange messages and information with their patients, while STOMP and test2stop use mobile text messaging for the

same effect. S-PC is set up to use Mobile text messaging but it can also use e-mail if that is required by the clinicians. Quit Genius use an app while TControl is the only one that uses a "different" mobile complement, it's also able to use e-mail when is needed. In the following chapters will be explained what makes TControl mobile complement that particular. Other web portal functionalities such as getting patients statistics and track its clinical history and treatment progression are only shared by PMC, S-PC, Quit Genius and of course TControl. Going a step further, only S-PC, Quit Genius and TControl have a specialist in charge of patients and able the clinicians to detect those that are on a risk situation, which are identified by the program that then notifies the doctor. Only S-PC and TControl permits to send custom messages at will to the patients and TControl it's the only one that allows direct chatting between clinician and patient.

While on the mobile apps side, we are going to compare TControl with the most likely ones among the top 20 best rated apps to quit smoking in 2020 [30].

TControl has some important differences compared with other current apps. These differences include patient monitoring, which provides the patient with the confidence of being monitored and assisted by a real doctor. TControl shows patient's evolution with charts, like Kwit, Smoke Free and Exfumador Pro do, but it also asks the patient's status every week.
TControl allows private chatting with a real doctor, as mentioned above.
TControl uses achievements and statistics to help the patients during their treatment, this is common on mostly every apps such as Quit Genius, Smoke Free, Kwit, Quit Now/Pro or Exfumador Pro. TControl achievements are mainly reminders of the goals and challenges met by the patient during the treatment such as non-smoked cigarettes, saved money, last smoking day or patient status evolution.
Psychological reinforcement of the patients' willpower is another important feature of TControl, because it is the only way to decrease the frequency of hospital visits by the patients. This saves a significant amount of time to the clinicians and increases the number of patients that they can simultaneously treat. We note that TControl is the only App that allows for personalized and customizable psychological reinforcement messages, managed by a real doctor. Some others like Kwit, Exfumador Pro or Quit Genius have a group of pre-established messages while TControl offers both, pre-established ones (generic) and clinicians can create their own and save it as templates for future usage.

We must also talk about S-PC, the system used in Xarxa d'Hospitals de Catalunya tobacco-quitting programs before TControl was implemented. S-PC is an e-medicine service based on a computer program that manages a central database of information on patient progression. It was also designed keeping in mind doctor-patient communication, that is why it has SMS System to send reinforcement messages and alerts to the patients and also ask

about their State.
The main differences that make changing to TControl an improvement decision are that it's web portal has been designed taking into account the strengths and weakness from S-PC, reported by its users. That feedback has been considered on the new UI design to improve system's usability, some changes were: remove fields or unused functionalities, add needed statistics, etc, but what really makes the difference is the doctor-patient communication. The SMS system has been deprecated in order to implement an alternative free messaging system, avoiding SMS cost, which keeps reinforcement messages and status questions functionalities but in a more comfortable and portable way for patients, clinicians and system performance. It also adds direct chat options between doctor and patient in order to make the follow-up process as custom and close as it could be.
TControl whole platform is fully detailed in the following chapters.

4. Methodology

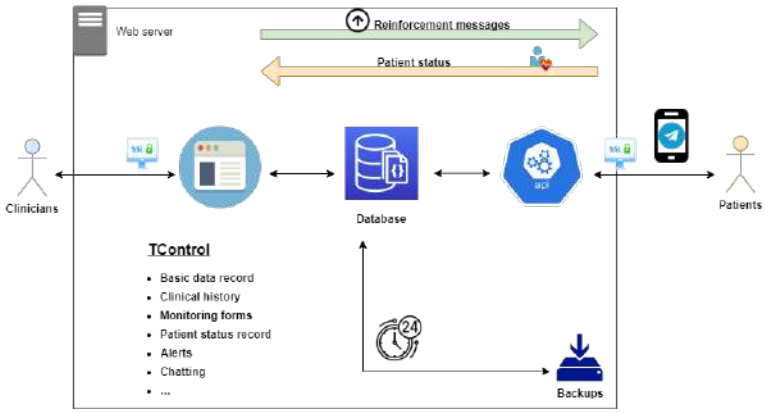


Figure 2: TControl operation.

TControl is a support platform for tobacco-quitting programs composed by 2 elements:

- Web portal
- Mobile complement

The web portal is the main component while the mobile complement is not mandatory, but used as an addition to take advantage from TControl platform. It's an extension added to expand communication between each specialist and its patients, since as it has been mentioned above, patient-doctor contact and follow-up are very important psychological aspects of the process of quitting smoking, because they provide support and help maintain patient reinforcement [21, 23].

Fig. 2 shows the overall operation of TControl. The SHUITE server is responsible for sending/receiving messages to/from TControl components. All communication between the SHUITE server and the TControl is encrypted using the HTTPS protocol. It also stores all the patient's medical information and clinical history introduced by the clinicians through TControl's web portal and the data, statistics and achievements of each patient from the mobile complement.

4.1. TControl: Web portal

The web portal is the main component of the TControl platform and is focused on clinical professionals in charge of smoking cessation programs. Currently, we can find a first version in working at the Xarxa d'Hospitals de Catalunya.

Among the general objectives of the platform, with this portal we want to facilitate the work of the clinicians, automating a large part of their work and thus reducing the time they need to devote to it, so they can attend to their patients in a more agile way.

The portal allows the specialists to manage everything related to their patients, from registering them to the cessation program, to scheduling new appointments, record the results of each appointment, the patient's medical history, among others.

They can also consult whenever they want the real time statistics of their patients, such as age, sex or even the status of the patients and their treatment.

As far as the patients' status is concerned, from the portal it is possible to monitor the evolution of each one of them from their answer to the question that is sent to them weekly in order to know their status regarding tobacco and treatment, which at the moment of performing it is notified to the specialist so they are informed of the new answer. They can also consult the patient's profile to see their evolution.

TControl is highly focused on doctor-patient communication, and that is why, from the same portal, clinics can communicate with their patients in different ways, by sending reinforcement messages to keep patients motivated to achieve their goal or directly contacting their patients or community. In this way they are in permanent contact without the need to schedule appointments and at the same time they can keep up to date with the status of their patients in a more proper way.

All the data received/generated from the TControl web portal is send to SHUITE server that stores it in an ever-growing MongoDB [36] database of patients, clinical histories and message texts. The database is encrypted and hosted on a secured server.

4.1.1. Design

TControl is a multi-platform, multi-language, application with a user-friendly graphical user interface (GUI) that enables easy access and utilization of all its functions by the clinician, implemented by using Javascript, CSS and Grails [37], an open source web application framework based on Apache Groovy [38], a language that integrates and interoperates with Java, the JVM, and existing Java EE containers and built on top of Spring Boot [39, 40] leveraging Spring Boot's time-saving features, such as Spring-powered dependency injection.

TControl has been developed following a client–server architecture (see Fig. 3). As mentioned above, different technologies were applied. The presentation layer is implemented using Groovy Server Pages (GSP) for the structure and CSS (Cascading Style Sheets) is used in the presentation. JavaScript is ideal for verifying web forms. Therefore, we use it for validation of submitted information to the server. Java Servlets has been used in the controller layer and Java in the model layer. CSS has been used for defining the presentation of a web document (HTML, XHTML, etc.). JDBC (Java Database Connectivity) allows the connection to the database. The database is implemented in MongoDB because of its performance and wide range of Application Programming Interfaces (APIs) available for it. All the used software is free and open source. The database stores information about clinical history of patients of each centre, messages and messaging, treatments and clinicians, etc.

English, Spanish, and Catalan languages are currently available. Additional languages can be easily added upon request.

TControl web portal can run on any computer, operating system (Linux, Windows, MacOS, iOS, Android, etc.), and on any of the major web-browsers (Firefox, Explorer, Chrome, Opera, Safari, etc.).

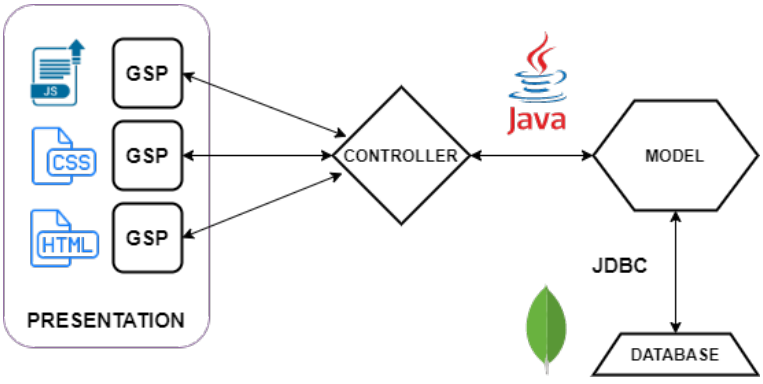


Figure 3: TControl architecture.

Usability criteria have been seriously taken into account when implementing whole TControl platform. The web portal has been designed in

order to be intuitive and easy to use, according to that it simply consists on a main page and unique lateral menu. In this way, users can access to any functionality with a single click, using a unique menu button located at the top left of the screen that is accessible from anywhere of the web-portal. That button appears or disappears at the user's will, making navigation simple and intuitive and improving the appearance of the portal.

As in the web portal implementation, Ad-hoc webservices are used to establish communication with SHUITE server using a secure HTTPS[1] protocol and exchanging data in JSON[2] format. The implementation avoids legal problems with clinical data that remain securely stored only in the SHUITE server. This necessary security comes associated with the small cost of obtaining the required information remotely. This cost does not significantly affect the user experience.

4.1.2. Operation

As commented in the chapter above, the design is really simple. Once the user, in this case clinicians, logs into the portal, the first that will see is the main window, that contains a dashboard which is divided into four sections (Fig. 4):

- The first one shows the last notifications, such as new patients registered in the software and by which users.
- In the second one, the user can see a graphical overview of its patient's status, so s/he can see fast if there is any critical situation, it also has a quick access link to the full functionality (explained below) in the case s/he needs more information.
- The third consists on a summary of the clinician chat inbox, where the messages to be read for each patient, if any, are indicated. Also, the total amount.
- And the last, the fourth, is an informative section that summarizes the recent activities that have been done on the platform, and who did it, for example new patients register.

TControl web portal has the following functionalities, which are explained separately below. Management features:

1. Patients' management.
2. Patients' statistics.

[1]HTTPS. Communication over Hypertext Transfer Protocol (HTTP) within a connection encrypted by Transport Layer Security (TLS).

[2]JSON. JavaScript Object Notation. Open standard format that uses human-readable text to transmit data objects.

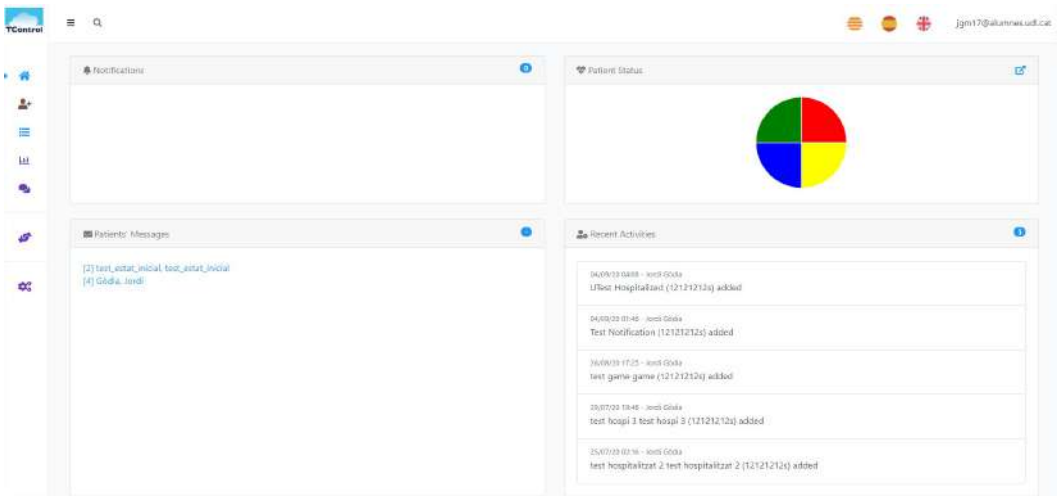


Figure 4: TControl home page.

Patient-clinician communication:

1. Allows chatting (instant messaging) between clinicians and their patients.
2. Sends status questions.
3. Sends personalized psychological reinforcement messages to prevent patients relapsing.

Patients management

In the TControl web portal, clinicians can realise the basic management operations related with patients such are: create, consult, modify and delete. What in the tobacco-quitting program would mean: register/enrol new patient to the program, consult their personal and clinical data and edit it or delete it if it was needed.

In order to register a new patient, the clinician must fill a form with some personal data to create a new profile, some of which will be significant for TControl functionalities. Those are:

- Patient type: In this field the clinician can choose between different options. The ones that are significant for TControl behaviour are "Ambulatory" and "Hospitalized" and it depends of the situation in which the patient entries to the tobacco-quitting program. Depending on these types, the patient's profile will have more or less information.

- D-day: The day that the patient will stop smoking or the last day that he smoked, important for some calculus and statistics.

- Communication channel: Here, the specialist can choose between "Mail", "Telegram" or "None" according to the patient's preference. It's im-

portant for communication functionalities such are Chat or Reinforcement messages.

- Initial status: Initially the state by default is "Abstinent" but the clinician can change it, for example in the case that the new patient hasn't started the program yet, then it could choose "Smoking", and come back to the patient's profile and edit it when it finally starts the treatment.

Other patient data that the clinician can manage it's the clinical history, but it depends on the patient types mentioned above. If it's a "Hospitalized" patient, its clinical history will only be composed by a complete form that contains patient's hospitalization details, both medical and casuistic, some data related with patient's tobacco consumption and information about possible treatments and assessments that the doctor has given to the patient. For last, in the case the patient accepts to enter the anti-smoking program, the doctor can fill some details about a new appointment when the patient leaves the hospital, when this happens, the next time they met, that patient's type will change to "Ambulatory".
Otherwise, clinicians can have more information from "Ambulatory" type patients. In this case, its clinical history is composed by:

- First visit: A form to be filled by the doctor during or after the first visit where its collected patients personal information such are its name, age, weight, the values of their constants in that medical examination, some information about patient's tobacco consumption and if it has followed any tobacco-quitting treatment, program or any other type of help before. Also, the last day that the patient smoked/will stop smoking and the next appointment date.

- Monitoring visit: In this form the doctor collects the values of patient's constants on that day, also some information about its current situation about tobacco such are: abstinence feeling, lapse or relapse, its pulmonary age or treatment effects evaluation.

- Treatments: A form that needs to be filled by the doctor, once for each medicine that is prescribed to the patient, keeping the details of the guideline that has been ordered to be followed and the observations that the specialist considers appropriate.

- Healthy habits: a form about patient's healthy habits such are feeding, physical activity, rest and consumption of psychostimulants. This form can be filled many times, and each of them keep being able to be consulted it in order to track patient's evolution in this topic.

This information will keep being accessible to be consulted in future to for example track patients progress.

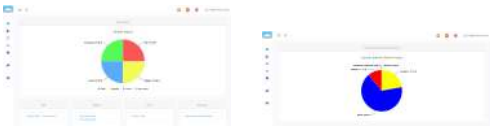
All this data is saved in SHUITE server secure database and can be modified by the clinician when it's needed.

Statistics

The clinician has access to different statistics in order to have as much information as possible about their patients. At the moment those are:

- Patient status: It shows the general graphical percentiles of the current status of patients. The individual status of each patient is also displayed.
- Treatment status: It classifies the total amount of patients related to that clinician in function of its clinical status which can be: Inactive, Active, Smoking, Relapse or Treatment completed.
- Patients sex: Same as before but classifying by patients' sex.
- Patients ages: Again, the same as before but classifying by patient's age, in this case the available ranges are: $\leq$20, 21-30, 31-40, 41-50, 51-60 and >60 years old.

In all cases the data is displayed in pie charts to make it clearer and easier to understand and measured as percentages. Are also important in order to realise studies and having a complete overview of the system situation. Examples in Figs. 5 and 6



(a) Patient status. (b) Clinical status.

Figure 5: Patient statistics examples.

(a) Patients gender. (b) Patients age.

Figure 6: Patient statistics examples.

Chatting

TControl web portal offers the clinicians the possibility to chat with its patients by instant messaging. Each patient has a chat window on its profile where the specialist can write and send private messages whenever it wants. Those messages will be received by the patient through its mail or TControl mobile complement, it depends what did they chose when enrolled into the

program. The patients' answers will appear in the same window and the clinician will get a notification to avoid messages being ignored.
Must be said that patients have the option of choose that they don't want communication, so in that case they wouldn't be able to chat and its only communication tool would be phone and physic appointments.

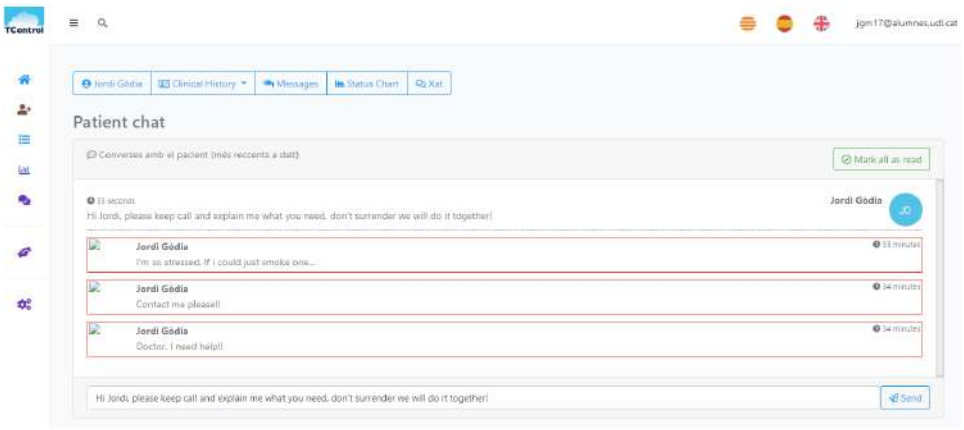


Figure 7: TControl chat.

Status questions.
Weekly, TControl automatically sends a status question to is patients, the media used for the communication can be mail or TControl mobile complement, it depends on patient's preference, saved when s/he is registered on the System. It asks the patient how is feeling about tobacco and treatment in a clear way, always being the same question to avoid patient's confusion. The question purpose is to follow each patient's progression through the treatment. Because of this, the answer is mandatory. The possible answers are sent with the question and those are: Bad, Regular, Good and Very good. Is done this way instead of asking patients for an open answer in order to make easier automated processing, storage, graphing, and analysis of the answers by the server.
The patients that don't answer those questions or answered with "Bad" or "Regular" are flagged as risk patients so the clinicians know when someone needs a personalized follow-up. The system relies on the honesty of the patient's answers.
All the information is organized in the database, and clinicians can access the list of patients at risk, and of patients that are not following the treatment appropriately, enabling a personalized treatment of each type of profile.

Reinforcement messages
In SHUITE server there is a collection of psychological reinforcement messages classified by patient status. Those messages are sent automatically to encourage the patient to continue the treatment in the anti-smoking program based on the patient current status, stored in SHUITE. The frequency

and number of reinforcement messages to be sent to each patient are fully customizable and managed by the clinicians through the web portal.

There is another type of messages, where the clinician is who creates it and decides who will be the receivers. S/he can also save the message created as a template in order to re-use it in future. These type of messages can have the same purpose as the automatic ones or can be used by the specialist as alerts if for example wants to notify some of its patients that X day will have to cancel all of their appointments or if s/he wants to share with them some resource that thinks that will be useful for all of them, instead of contact them one by one.

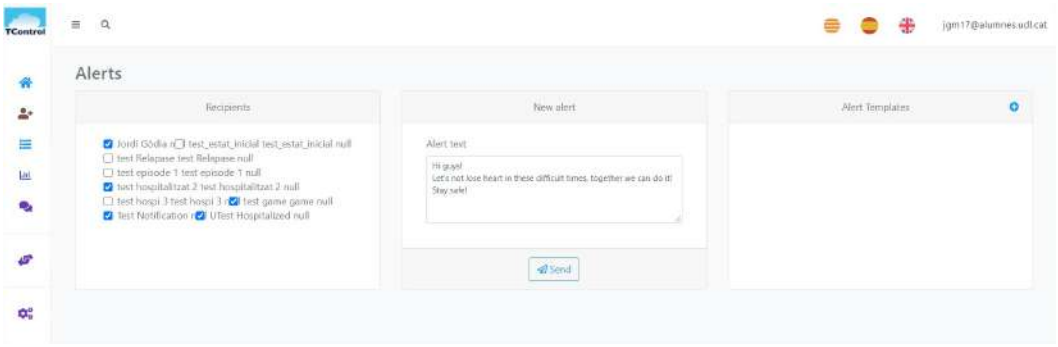


Figure 8: TControl custom messages and alerts.

4.2. TControl: Mobile complement

TControl's Mobile complement has been designed to extensively expand the current system of communication with the SHUITE server, offering an easier way to keep in touch patients and specialists. While the web portal it's more oriented to clinicians, this complement is focused on patients. It is available for all those patients who are already registered in the system since the user's mobile phone number is required in order to use the add-on and are enrolled on the tobacco-quitting plan.

Patients can use TControl's mobile complement to send weekly reports from a smartphone to the SHUITE server by filling a small form, via Internet. SHUITE receives these reports and stores them in an ever-growing database of clinical histories and message texts. The database is encrypted and hosted on a secured server. Each time the patient answers to the status question, its clinician responsible receives a chat message on the web portal with their current status in order to keep them always updated so they can give provide feedback or assistance to their patients without need to set an appointment.

TControl's mobile complement can also be used for semi-automated self-monitoring and psychological support of patients, via statistics/achievements.

It also throws push reinforcement messages scheduled by the clinician to enhance the willpower of the patient. Achievement and reinforcement messages can be sent from the web portal to a particular patient or to every member of a health plan group.
Can also be used by the patients to send messages directly to their responsible web portal inbox whenever they need and they will receive the clinician answer in the same chat if he thinks it is feasible, or will call him back otherwise. And provides the patient a possibility of leisure by a very entertaining web-browser embedded game.

For last, but not less important, it acts like "panic button" in the case that patient smokes again, warning the clinical about the relapse so he can procedure as it sees fit, for example sending back a message, calling the patient or arranging an appointment. It must be said that if this happens, from that moment the patient will have restricted access to TControl's mobile complement features since they are oriented to those patients on tobacco-quitting plan and he has become again a "smoker" but will keep the possibility to contact their medical responsible.

Figure 9 symbolises the interaction of the patient with the application and all its variables.

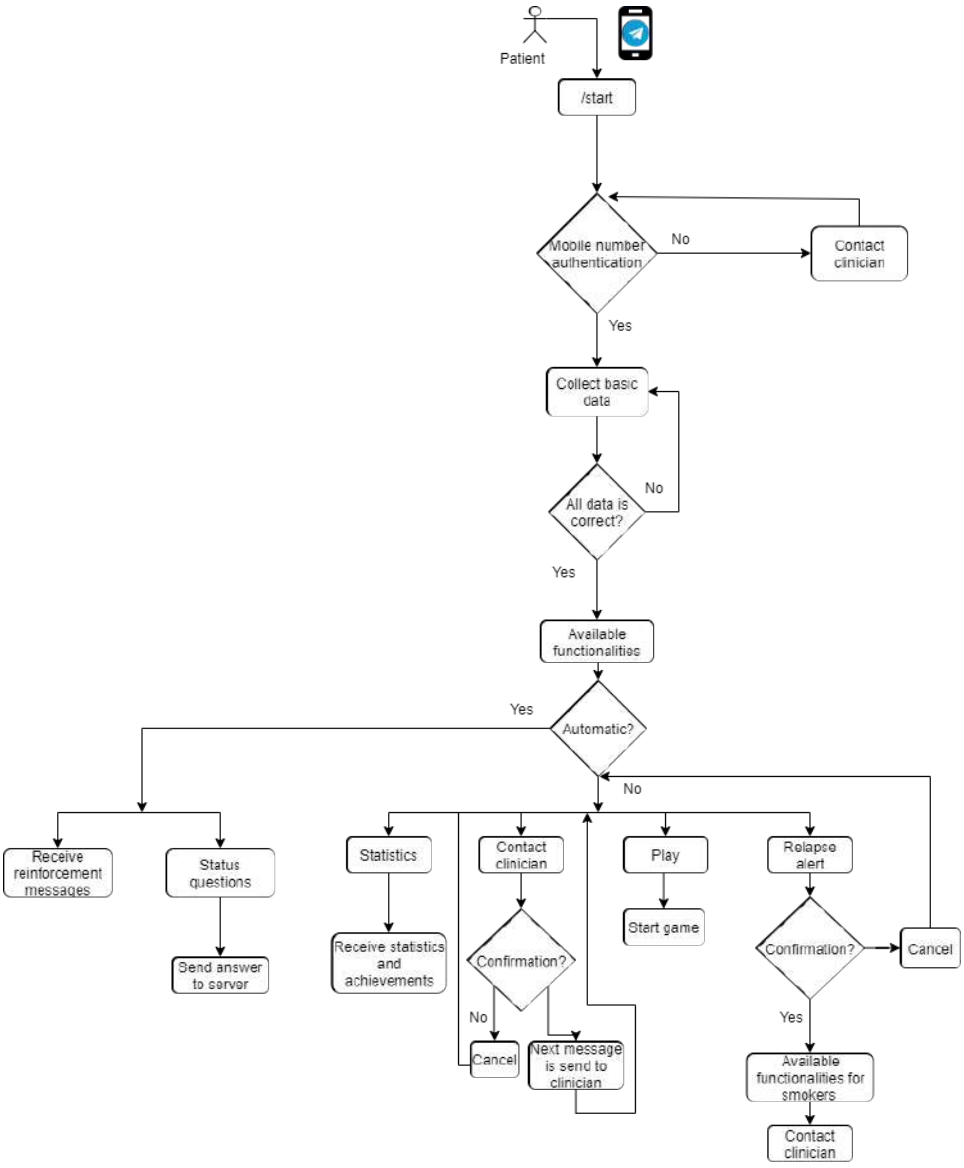


Figure 9: TControl bot: patient's interaction flowchart.

4.2.1. Design

Nowadays, when we talk about a "mobile complement" most of the people would think about an app. In this case, for TControl even we could have developed one, we decided to make it in a different way. Three important design requirements were that the application should be compatible with Android and iOS, the most popular mobile operating Systems, while guarantee optimal performance and communication security. Functional requirements were collected from the clinicians of the Tobacco Unit of the Xarxa d'Hospitals de Catalunya. This is why we decided to implement TControl's

mobile complement as a Telegram Bot instead of creating a brand-new app native for each store taking profit from the advantages provided by a verified platform such is Telegram and the versatility that offers their open API [41]. It has been implemented using JAVA, one of the languages allowed by this API and the point on do it this way is that take profit from an already existing secure communication system, it's proved performance and the fact that its available for both, Android and iOS markets, fitting perfectly all of our requirements. It's honest to recognise that this has been possible since we could handle all of the TControl's mobile complement features this way because it fits all of our needs as a charm, otherwise wouldn't had been an option since as an API has limitations that can't we deal with. In that case would had been necessary to develop native apps.

Usability criteria have been seriously taken into account too when implementing the Telegram Bot, we take advantage of Telegram's clean UI and all features have been organized as a button keyboard, having as many buttons as features, so the users' access to any functionality is a single click away. That keyboard disappears if the bot is waiting an action from the patient, so the user knows that way that something is missing from his side, and appearing back when the action it's completed, making navigation simple and intuitive.

Ad-hoc webservices are used to establish communication with SHUITE using a secure HTTPS[3] protocol and exchanging data in JSON[4] format. The implementation as a Telegram Bot ensures low data capacity requirements in the device since it doesn't require of an app installation, only Telegram that in most cases it's already installed in user's device and open a new chat to TControl bot. It also avoids legal problems with clinical data that remain securely stored only in the SHUITE server and never in the devices. This necessary security comes associated with the small cost of obtaining the required information remotely. This cost does not significantly affect the user experience and we also avoid the need of using a third party's software to implement a complete and efficient push notification service to keep it free.

4.2.2. Operation

Users must be accepted by a hospital and be added to a treatment plan before can use TControl bot functionalities. Upon using TControl bot for the first time, users fill a form to answer several questions: date that they

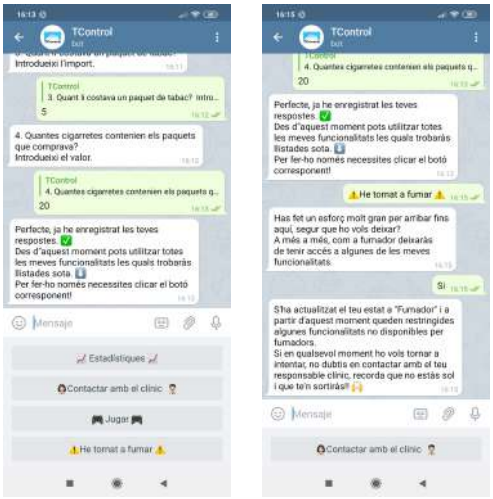
[3]HTTPS. Communication over Hypertext Transfer Protocol (HTTP) within a connection encrypted by Transport Layer Security (TLS).

[4]JSON. JavaScript Object Notation. Open standard format that uses human-readable text to transmit data objects.

stopped smoking, number of cigarettes s/he used to smoke, expenditure on tobacco, etc. The answers are used to prepare the initial statistics and achievements for that patient. The user can only see the main UI after filling this form.

The interface is composed by Telegram buttons keyboard, with a button for each of the available functionalities for that user. It exists two keyboard composition possibilities that depend on user's State:

1. While s/he is on the tobacco-quitting plan: In this case will be able to use all of TControl bot functionalities.
2. Smoker keyboard: This happens when the user has pressed the "I'm smoking again" button and confirmed that he has relapsed, in that case s/he would be automatically out from tobacco-quitting program and will only be able to contact with its clinical responsible for the case s/he needs help or wants to try it again in the future.



(a) Patient functionalities.

(b) Smoker functionalities.

Figure 10: TControl bot available functionalities.

The TControl bot has the following functionalities:

1. Registers the patient's compulsion to smoke and sends it to the SHUITE server.
2. Receive personalized psychological reinforcement messages to avoid patients relapsing.
3. Permits the patient to consult their statistics and achievements.
4. Permits chatting (instant messaging) between patients and clinicians (or medical team).

5. Permits the patient to notify that has relapsed.
6. Also includes a game for the user to be distracted.

The main functionalities are explained separately below.

Registering compulsion to smoke.
Weekly, the patient receives a Telegram message through TControl bot asking about their current status about tobacco and offering 4 options in a new buttons keyboard, each of them accompanied with an emote that helps to represent patient's feelings.

When patient chooses an answer, TControl bot sends the choice to the SHUITE server where its saved and immediately answers with a short message that provides psychological support and advice to the user. This support is personalized and depends on the status of the patient. There are four possible states (emotes):

- Bad (sad)
- Regular (regular)
- Good (happy)
- Very good (very happy)

Each of them has different associated messages to each one, scheduled in a round-robin way. Once the user has answered the status question, when TControl bot answers back with the reinforcement message it set up again the default keyboard so he can access all functionalities again. Example on Fig. 11

Figure 11: TControl bot status question.

Reinforcement messages

Each TControl patient has several psychological reinforcement messages assigned to him/her. These messages are personalized and managed by the clinician in charge. The frequency and number of reinforcement messages to be sent to each patient are also fully customizable. These messages are sent to the patient to encourage the patient to continue the treatment in the anti-smoking program and depends on the status of the patient. For example, a patient could receive a daily notification message in their smartphone to improve their mood. By default, are sent twice a week.

Another advantage from TControl is that the old S-PC did this by SMS what supposes a cost by message to take into account, while Telegram message system is completely free.

Figure 12: TControl bot reinforcement messages.

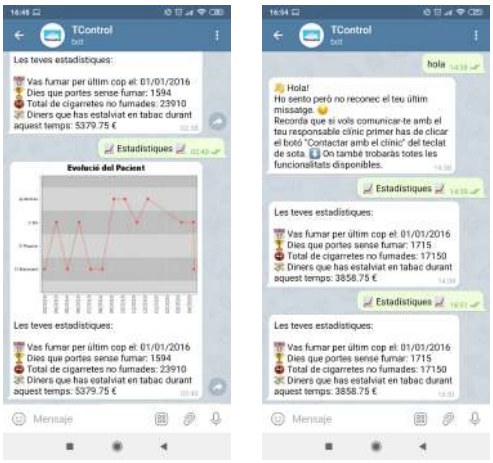
Statistics and achievements.

The patient can consult whenever s/he wants his statistics and achievements just pressing one button. When s/he does it, the TControl sends a query to SHUITE server to retrieve the data provided by the user the first time that used the bot in order to calculate the patient's achievements. The main are:

- Last smoke day: Entered by the user the first-time s/he used the bot.
- Days without smoking: Calculated from last smoke day.
- Total non-smoked cigarettes: Calculated based on the cigarettes smoked per day, amount provided by the user.
- Money saved since beginning of the program: Based on the price per packet that used to buy the patient, amount provided by the user.

As an extra, if the user has registered at least 4 status responses (taking 4 as a minimum since the question is send once a week what it means having

at least 1 month of user status tracking), TControl will retrieve its status responses and build a graph that will be send to the patient's chat attached to the statistics and achievements message, with the objective that the user can track all his psychological evolution about tobacco. The data shown on the graph is limited to 1-year status responses in order to keep the graphic clear and understandable.



(a) Patient statistics. (b) Patient statistics with status tracking.

Figure 13: TControl bot statistics and achievements.

Contact with the clinician.

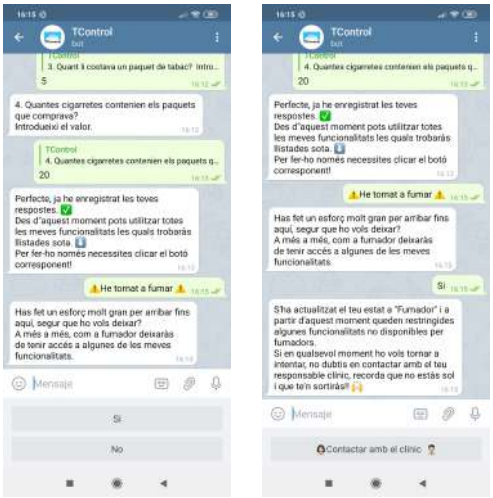
Whenever the patient need to send a message to its clinician, it will only need to press the correspondent button from the functionalities menu (keyboard), once s/he does it, TControl bot will answer back with an informative message to let the patient know that the next message that s/he sends will go directly to its clinician chat inbox from TControl web portal. It must be said that it is necessary to press that button for each message that want to be send. When the medical in charge saws the message in the web portal, would be able to answer back from the chat inbox and the patient will receive immediately that answer through TControl bot. Example on Fig. 14

Notify relapse.

This functionality has the objective to warn the clinician that its patient has relapsed. As mentioned above, it acts like a "panic button" in the case that patient smokes again. When it's pressed, TControl bot sends a message to the patient asking him to confirm the cancel, in order to avoid fake alarms. If the patient confirms it, then a message warning is sent to the medical responsible as a warning for the patient relapse so he can procedure as it sees fit, for example sending back a message, calling the patient or arranging an

Figure 14: TControl contact clinician.

appointment. As explained before, when this happens, from that moment the patient will have restricted access to TControl's mobile complement features since they are oriented to those patients on tobacco-quitting plan and he has become again a "smoker" but will keep the possibility to contact their medical responsible.



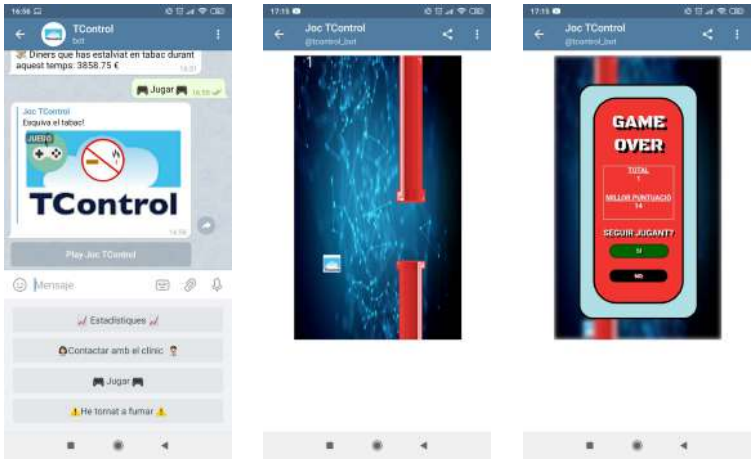
(a) Relapse alert. (b) Confirmation.

Figure 15: TControl bot relapse alert.

Play.

TControl bot provides the patient a possibility of leisure by a very entertaining web-browser embedded game. The game is based on a famous game that for sure will result familiar to most of the users, adapted to TControl

tematic, that ensures fun and entertainment.
Telegram bot API offers the possibility of create your own games [42], register it as a new game on their API for the affected bot so whenever the patient wants to play only needs to press the correspondent button from the chat keyboard and TControl bot will open the linked game on Telegram's embedded browser. Doing it in this way, the game is developed and hosted on SHUITE server so neither Telegram or user's device will suffer from extra space issues.
The game has been developed mostly with JavaScript [43] for the logic-side and HTML5 [44] for the graphics. The user's best score is saved into the SHUITE server.



(a) Game intro. (b) Game. (c) Game over.

Figure 16: TControl bot game.

4.3. Stability

TControl has been tested with 25 users to analyse the failures and stability before publish it officially. This has been carried on by collecting exhaustive information about crashes from logs and testers feedback.

4.4. Usability

To measure the usability of TControl, we performed a short survey using the industry standard System Usability Scale (SUS) [45] tool. It consists of a 10 item questionnaire with five response options for respondents; from Strongly agree to Strongly disagree. Originally created by John Brooke in 1986, it allows you to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications. We have chosen SUS since its characteristics fit perfectly with our interests:

- Very easy scale to administer to participants.

- Can be used on small sample sizes with reliable results
- Is valid – it can effectively differentiate between usable and unusable systems.

Participants will rank each question from 1 to 5 based on how much they agree with the statement they are reading. 5 means they agree completely, 1 means they disagree vehemently.
The survey was answered by all TControl tester users. The group contains representative proportions of age, sex and physical condition with respect to the complete treatment group. Also half of them are smokers, so they may be potential users in the future, especially after the good opinions generalized after participating in the test program.
As a last clarification, SUS is not diagnostic.

4.5. Performance

To asses server's robustness and performance, TControl it's connected to a monitoring service that collects the up-time and response times as well as the time it has been down caused by any error. The following Figure 17 shows an extract of these statistics, as you can see in the image the server has been active without errors for more than 3100 hours, which would be 131,875 days!

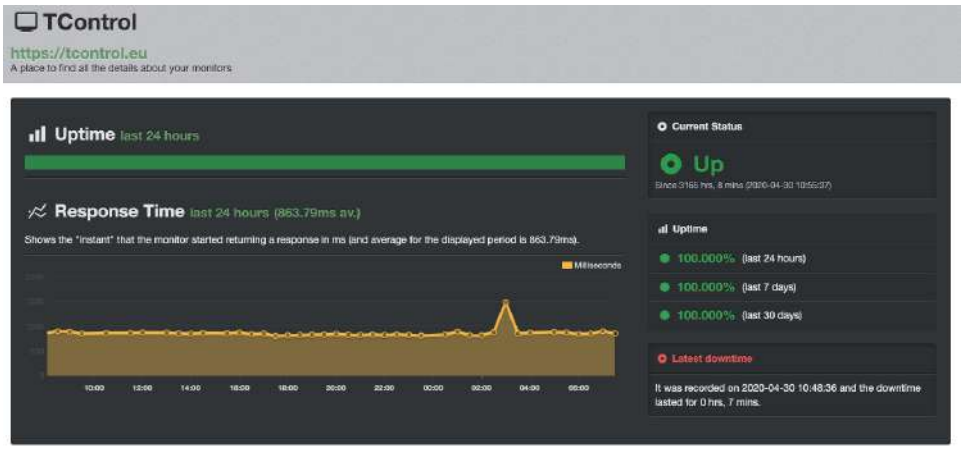


Figure 17: Server monitoring service.

About TControl mobile complement, if this was a typical app, in this chapter we would assess the performance of TControl when executing its most critical operations but since we are dealing with a Telegram bot, the limitations that this implies are explained below: Currently, Telegram is limited to sending a maximum of 100 requests per second to your back-end. The sooner you are able to process this request and reply, the sooner users will see the changes in the bot client.

However, the problem starts when the back-end is unable to process the user's request or puts it in a queue to be processed. Whenever the Telegram API detects a request has not been processed, it will start to repeatedly resend the request, flooding the back-end on its own. Only one minute of downtime is enough for a high-performance bot to receive a backlog of 5 to 15 minutes because of these repeated requests called "REQUIREMENTS OF PROVIDED CALLS".

Knowing these limitations, even our bot is a specific usage, and never happened during the trial period, it is possible that It is possible that occasionally there will be some small delay in the bot's response, which will not be due to the performance of the server but to the ability of the API to process and send the requests.

5. Results

In this section, the robustness and usability of TControl platform are tested.
To make a rigorous evaluation of TControl's web portal's **robustness**, we recorded all the crashes that occur when using the application, to control where and when they occur.
For the TControl bot, as it depends largely on Telegram, has been taken into account the issues on the backend caused from mobile complement interaction.

To measure **usability**, a balanced sample of 25 tester users summarized in Table 1), representing different social levels, professional activities, technical profile, age and gender were chosen. As an extra, about half of them are currently smoking, what it means they are potential real users.
Changes made based on their observations helped to make TControl more user-friendly.
People had to perform various actions within the mobile complement and the web-portal.
In the case of the web portal, the users were asked to:

1. Register new patients
2. Consult the statistics
3. Send reinforcement messages
4. Chat with patients

While for the mobile complement, the users were required to test all the able functionalities.
Concretely the tasks to carry on were:

1. Start a new conversation with the bot
2. Fill initial form
3. Receive and answer status question

4. Consult statistics
5. Chat with clinicians
6. Play

Feature	Class	Participants
Gender	Male	12
	Female	13
Age	<30	17
	30-65	8
Smoker	Yes	14
	No	11
Technological profile	Yes	18
	No	7
Total		25

Table 1: Test-participant features.

As has been mentioned in correspondent Usability chapters above, System Usability Scale (SUS) has been used to evaluated the platform usability, so all the testers had to fill one SUS survey for web portal and one for the mobile complement.

5.1. Robustness

After a 15 days test period, a total of 17 crashes were detected on the web portal, while only 6 on the mobile complement.
Most of them (around 80%) were produced by database exceptions due to bad queries and wrong data treatment or due to simple programming errors (9%) as unexpected casuistic, also few communication errors between client and server (11%).

5.2. Usability

The first users who evaluated TControl had a positive attitude towards the platform and in general, they think it exhibits good usability. Table 2 Shows SUS results from TControl web portal, while Table 3 collects TControl mobile complement ones. As a reminder, SUS questions are ranked from 1 to 5 based on how much the user agrees with the statement. 5 means they agree completely, 1 means they disagree vehemently.

The results of the questionnaire are extracted as follows [46]:

- X = Sum of the points for all odd-numbered questions – 5
- Y = 25 – Sum of the points for all even-numbered questions
- SUS Score = (X + Y) x 2.5

Question	1	2	3	4	5
1. I think that I would like to use this system frequently.	-	-	-	4	21
2. I found the system unnecessarily complex.	25	-	-	-	-
3. I thought the system was easy to use.	-	-	-	7	18
4. I think that I would need the support of a technical person to be able to use this system.	19	6	-	-	-
5. I found the various functions in this system were well integrated.	-	-	-	10	15
6. I thought there was too much inconsistency in this system.	25	-	-	-	-
7. I would imagine that most people would learn to use this system very quickly.	-	-	-	2	23
8. I found the system very cumbersome to use.	21	4	-	-	-
9. I felt very confident using the system.	-	-	1	4	2
10. I needed to learn a lot of things before I could get going with this system.	22	3	-	-	-

Table 2: TControl: web-portal SUS results.

Question	1	2	3	4	5
1. I think that I would like to use this system frequently.	-	-	-	1	24
2. I found the system unnecessarily complex.	25	-	-	-	-
3. I thought the system was easy to use.	-	-	-	-	25
4. I think that I would need the support of a technical person to be able to use this system.	25	-	-	-	-
5. I found the various functions in this system were well integrated.	-	-	-	3	22
6. I thought there was too much inconsistency in this system.	24	1	-	-	-
7. I would imagine that most people would learn to use this system very quickly.	-	-	1	4	20
8. I found the system very cumbersome to use.	25	-	-	-	-
9. I felt very confident using the system.	-	-	-	-	25
10. I needed to learn a lot of things before I could get going with this system.	25	-	-	-	-

Table 3: TControl: mobile-complement SUS results.

The rationale behind the calculation is very intuitive. The **total score is 100** and each of the questions has a weight of 10 points.
As odd-numbered questions are all in a positive tone, if the response is **strongly agree**, you will want to give them the **maximum point** which is 10 for each question. If the response is strongly disagree, you will want to give them the minimum point which is 0. By subtracting 1 from each of the odd-numbered questions, you ensure that minimum is 0. After which, by multiplying by 2.5, you ensure that the maximum is 10 for each of the questions.
Vice versa, for the even-numbered questions in a negative tone, if the response is **strongly agree**, you will want to give them the **minimum point** which is 0 for each question. If the response is strongly disagree, you will want to give them the minimum point which is 0. As such, by subtracting the points of each question from 5, you ensure that minimum is 0. After which, by multiplying by 2.5, you ensure that the maximum is 10 for each of the questions.
Table4 collects participant's individual scores.

Participant	Web-Portal	Bot
1	90	100
2	97.5	100
3	82.5	97.5
4	95	100
5	97.5	97.5
6	97.5	100
7	92.5	100
8	100	100
9	95	97.5
10	100	100
11	100	100
12	95	100
13	100	100
14	95	97.5
15	100	100
16	97.5	100
17	100	100
18	97.5	95
19	100	97.5
20	95	100
21	100	100
22	85	85
23	100	97.5
24	80	100
25	95	97.5

Table 4: Participants individual SUS scores.

Once all the results have been obtained, we calculate the average value for each test, thus obtaining the final score. In our case, we got a **95.8** on web-portal side and a **98.8**. Those results are incredibly satisfying since according to the general guideline of the interpretation of a SUS score (Table5), we achieved an A grade on both, what it means an excellent.

The result obtained is consistent with the sensations shared by the users after doing the different tests. All of them consider that the web part is very intuitive and that it does not require much time to learn how to get the most profit from it, while about the bot all of them highlight its simplicity - usefulness relationship

6. Discussion

TControl platform offers the main functionalities to support clinicians and patients of tobacco-quitting programs.
Is robust and user-friendly since most of the users that took the test indicated that it was not difficult to use, as shown in the Results section.

SUS score	Grade	Adjective Rating
greater than 80.3	A	**Excellent**
68 - 80.3	B	**Good**
68	C	**Okay**
51 - 68	D	**Poor**
less than 51	F	**Awful**

Table 5: General guideline on the interpretation of SUS score.

TControl is effective, useful and perceived as an added value to treatment by old S-PC consulted users and tester users, they also see possibilities for applying similar tools in other health treatments.

The time management of clinicians will be significantly improved and the time dedicated to personalized clinical attention to patients that are at risk and require closer follow-up, will increase significantly and clinicians will be able to Schedule and manage that time more effectively. TControl it also avoids unnecessary travel while allowing patients to feel closely followed up by the clinician, really important things when the public health system situation is as critical as it is in the days of COVID-19.

Table 6 presents a comparison of the functionalities of other popular systems, mentioned at the beginning of this article, to show that TControl is the one with more complete set of functionalities.

	STOMP	**PMC**	**TEST2STOP**	**S-PC**	**TControl**
Clinician support	Yes	-	Yes	Yes	**Yes**
Communication channel	SMS	E-mail	SMS	E-mail SMS	**E-mail Telegram**
Charts	No	Yes	No	Yes	**Yes**
Lists	No	Yes	No	Yes	**Yes**
Medical history	No	Yes	No	Yes	**Yes**
Doctor chatting	No	No	No	No	**Yes**
Custom messages	Yes	Yes	Yes	Yes	**Yes**
Custom alerts	No	No	No	Yes	**Yes**
Templates	No	No	Yes	Yes	**Yes**

Table 6: Comparing TControl system with other similar tools.

It is difficult to compare the performance of the bot since after analyzing the Telegram community, we could not find any other bots for this purpose.

There are indeed channels to provide support for quitting smoking at the same time as users create a community among themselves. As for comparing it to mobile applications that have the same purpose as our bot, given the obvious difference in implementation, it can only be compared at the level of functionality.

In this case, Table 7 Compares TControl's bot functionalities and the ones that offer some of the best rated apps, also introduced on Related work section. Even all of them share some functionalities, the fact that TControl permits direct chatting between doctor and patient plus the fact that provides personalized psychosocial reinforcement messages make the difference to put TControl on top.

	KWIT	**SMOKE FREE**	**EXFUMADOR PRO**	**QUIT GENIUS**	**QUIT NOW/PRO**	**TControl**
Clinician monitoring	No	No	No	Yes	No	**Yes**
Charts	Yes	Yes	Yes	Yes	No	**Yes**
Doctor chatting	No	No	No	No	No	**Yes**
Psychological reinforcement messages	Yes	No	Yes	Yes	No	**Yes**
Custom psychological reinforcement messages	No	No	No	No	No	**Yes**
Statistics and achievements	Yes	Yes	Yes	Yes	Yes	**Yes**

Table 7: Comparing TControl bot with other similar apps.

What none of these have is the degree of customization and closeness between professional and patient that it offers TControl mobile complement. These results are encouraging and complement the results found in earlier studies. Our findings reassert that the use of mobile phone interventions may be effective in increasing the long-term abstinence rates in smoking patients, and that positive reinforcements messages and the usage of technology-based interventions can be an effective complement to the current smoking cessation programs.

7. Conclusions and Future Work

This article presents TControl, a complete platform to provide potential tobacco-quitting stakeholders the best support based on their needs and goals in order to facilitate their work and improve user's satisfaction for both, clinicians and patients, what indeed means to improve the success of the program. It is also important to understand the contextual usage of the platform and how important are the communication services to accomplish that success.

As mentioned above, the obtained results are encouraging and satisfy our work. We are sure that TControl can be really useful for clinicians and that will make the difference for patients against other systems.

Abstinence rates tend to decay over time, and a longer study implies higher levels of relapse among patients. However, our trial had some limitations regarding the number of patients involved in the study. Further larger studies should be performed to verify the current results.

Taking that into account, our immediate objective is to go live with the full version of the TControl platform implementing it on the "Xarxa d'Hospitals de Catalunya" in order to keep testing it and analysing the results with a larger sample, in order to compare it with the gathered on this test period with the objective to consolidate our projects success.

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